Extraction of cross section after corrections from ZDC efficiency and pile-up

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Definitions (1/2)

ε^A	Efficiency to detect ZNA activity.
ε^C	Efficiency to detect ZNC activity.

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ε^{C}	Efficiency to detect ZNC activity.

P^{A}	Probability of pile-up in ZNA (measured with CTRUE, it includes ZN efficiency)
P^{C}	Probability of pile-up in ZNC (measured with CTRUE, it includes ZN efficiency)

Definitions (2/2)

σ^{fit}_{0n0n}	cross section of the 0n0n class from the fit; that is, before corrections for ZDC pile-up and efficiency
σ^{fit}_{0nXn}	cross section of the 0nXn class from the fit; that is, before corrections for ZDC pile-up and efficiency
σ^{fit}_{Xn0n}	cross section of the Xn0n class from the fit; that is, before corrections for ZDC pile-up and efficiency
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σ^{M}_{0n0n}	cross section of the 0n0n class after correction for ZDC pile-up and efficiency
σ^{M}_{0nXn}	cross section of the 0nXn class after correction for ZDC pile-up and efficiency
σ^{M}_{Xn0n}	cross section of the Xn0n class after correction for ZDC pile-up and efficiency
σ^{M}_{XnXn}	cross section of the XnXn class after correction for ZDC pile-up and efficiency

Equation for σ^{fit}_{0n0n}

$$\sigma^{fit}_{0n0n} = \sigma^{M}_{0n0n}$$

Equation for σ^{fit}_{0n0n}

$$\sigma^{fit}_{0n0n} = \sigma^{M}_{0n0n} - \sigma^{M}_{0n0n}[P^{A}(1- P^{C})+ P^{C}(1- P^{A}) + P^{A}P^{C}]$$

Loses due to pile-up in 0n0n

Equation for σ^{fit}_{0n0n}

$$\sigma^{fit}_{0n0n} = \sigma^{M}_{0n0n}$$

$$- \sigma^{M}_{0n0n}[P^{A}(1- P^{C})+ P^{C}(1- P^{A}) + P^{A}P^{C}]$$

$$+ \sigma^{M}_{Xn0n}(1-\varepsilon^{A})(1- P^{A})(1- P^{C})$$

Loses due to pile-up in 0n0n

gains due to efficiency losses in Xn0n

Equation for σ^{fit}_{0n0n}

$$
\begin{aligned}
\sigma^{fit}_{0n0n} = \sigma^{M}_{0n0n} \\
& - \sigma^{M}_{0n0n}[P^A(1- P^C)+ P^C(1- P^A) + P^A P^C] \\
& + \sigma^{M}_{Xn0n}(1-\varepsilon^A)(1- P^A)(1- P^C) \\
& + \sigma^{M}_{0nXn}(1-\varepsilon^C)(1- P^A)(1- P^C)
\end{aligned}
$$

Loses due to pile-up in 0n0n

gains due to efficiency losses in Xn0n

gains due to efficiency losses in 0nXn

Equation for σ^{fit}_{0n0n}

$$\sigma^{fit}_{0n0n} = \sigma^{M}_{0n0n}$$

$$- \sigma^{M}_{0n0n}[P^A(1- P^C)+ P^C(1- P^A) + P^A P^C]$$

Loses due to pile-up in 0n0n

$$+ \sigma^{M}_{Xn0n}(1-\varepsilon^A)(1- P^A)(1- P^C)$$

gains due to efficiency losses in Xn0n

$$+ \sigma^{M}_{0nXn}(1-\varepsilon^C)(1- P^A)(1- P^C)$$

gains due to efficiency losses in 0nXn

$$+ \sigma^{M}_{XnXn}(1-\varepsilon^A)(1-\varepsilon^C)(1- P^A)(1- P^C)$$

gains due to efficiency losses in XnXn

Equation for σ^{fit}_{0nXn}

$$
\begin{aligned}
\sigma^{fit}_{0nXn} = \sigma^{M}_{0nXn} \\
&- \sigma^{M}_{0nXn}(1-\varepsilon^{C})(1-P^{C})[(1-P^{A})+P^{A}] \\
&- \sigma^{M}_{0nXn}[\varepsilon^{C}P^{A} + (1-\varepsilon^{C})P^{A}P^{C}) \\
&+ \sigma^{M}_{0n0n}(P^{C})(1-P^{A}) \\
&+ \sigma^{M}_{Xn0n}(1-\varepsilon^{A})(1-P^{A})P^{C} \\
&+ \sigma^{M}_{XnXn}(1-\varepsilon^{A})(1-P^{A})[\varepsilon^{C} +(1-\varepsilon^{C})P^{C}]
\end{aligned}
$$

Loses into 0n0n+Xn0n

Loses into XnXn

gains due to pile-up in 0n0n

gains due to efficiency losses in Xn0n

gains due to efficiency losses in XnXn

Equation for σ^{fit}_{Xn0n}

$$
\begin{aligned}
\sigma^{fit}_{Xn0n} = \sigma^{M}_{Xn0n} \\
&- \sigma^{M}_{Xn0n}(1-\varepsilon^{A})(1-P^{A})[(1-P^{C})+P^{C}] \\
&- \sigma^{M}_{Xn0n}[\varepsilon^{A}P^{C} + (1-\varepsilon^{A})P^{A}P^{C}) \\
&+ \sigma^{M}_{0n0n}(P^{A})(1-P^{C}) \\
&+ \sigma^{M}_{0nXn}(1-\varepsilon^{C})(1-P^{C})P^{A} \\
&+ \sigma^{M}_{XnXn}(1-\varepsilon^{C})(1-P^{C})[\varepsilon^{A} + (1-\varepsilon^{A})P^{A}]
\end{aligned}
$$

Loses into 0n0n+0nXn

Loses into XnXn

gains due to pile-up in 0n0n

gains due to efficiency losses in Xn0n

gains due to efficiency losses in XnXn

Equation for σ^{fit}_{XnXn}

$$\sigma^{fit}_{XnXn} = \sigma^{M}_{XnXn}$$

$$- \sigma^{M}_{XnXn}(1-\varepsilon^{A})(1-P^{A})[\varepsilon^{C}+(1-\varepsilon^{C})P^{C}]$$

Loses due to efficiency in 0nXn

$$- \sigma^{M}_{XnXn}(1-\varepsilon^{C})(1-P^{C})[\varepsilon^{A}+(1-\varepsilon^{A})P^{A}]$$

Loses due to efficiency in Xn0n

$$- \sigma^{M}_{XnXn}(1-\varepsilon^{A})(1-\varepsilon^{C})(1-P^{A})(1-P^{C})$$

Loses into 0n0n

$$+ \sigma^{M}_{0n0n}(P^{A}P^{C})$$

gains due to pile-up in 0n0n

$$+ \sigma^{M}_{0nXn}[\varepsilon^{C}P^{A}+(1-\varepsilon^{C})P^{A}P^{C}]$$

gains due to pile-up in 0nXn

$$+ \sigma^{M}_{Xn0n}[\varepsilon^{A}P^{C}+(1-\varepsilon^{A})P^{A}P^{C}]$$

gains due to pile-up in Xn0n

Solving the equation

- Add the equations: $\sigma^{fit}_{Xn0n} + \sigma^{fit}_{0nXn}$
- Assume that $\sigma^{M}_{Xn0n} = \sigma^{M}_{0nXn}$
- Solve the remaining 3 equations to find the cross sections after the corrections

Results from an example

- As an **example**, use as input:
  - $\varepsilon^A = 0.93 \pm 0.01$
  - $\varepsilon^C = 0.93 \pm 0.01$
  - $P^A = 0.031 \pm 0.003$
  - $P^C = 0.032 \pm 0.003$
  - $\sigma^{fit}_{0n0n} = 450$
  - $\sigma^{fit}_{Xn0n} + \sigma^{fit}_{0nXn} = 50$
  - $\sigma^{fit}_{XnXn} = 10$

Results from an example

- Cross sections change as follows
  - 450 -> 477.66 (+6%),
  - **50 -> 22.10, (-66%)**
  - 10->10.25 (+2.5%)

- As an **example**, use as input:
  - $\varepsilon^A = 0.93 \pm 0.01$
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- The uncertainty due to uncertainty on efficiency is
  - σ^{M}_{0n0n} : **-/+** 0..05 %
  - $\sigma^{M}_{Xn0n} + \sigma^{M}_{0nXn}$: ±0.08 %
  - **σ^{M}_{XnXn} : ± 2.2 %**
- The uncertainty due to uncertainty on pile-up is
  - σ^{fit}_{0n0n} : **-/+** 0.7%
  - **$\sigma^{fit}_{Xn0n} + \sigma^{fit}_{0nXn}$: +16/-12 %**
  - σ^{fit}_{XnXn} : ±0.8%

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  - σ^{fit}_{XnXn} : ±0.8%

Extreme dependence on pile-up due to migrations from 0n0n to Xn0n+0nXn classes and the absolute size of the respective corss sections

In this example, 0n0n and XnXn are the best option to extract the γPb cross section

Next steps

- Use the actual values for cross sections, pile-up, efficiencies and uncertainties
- Attempt to extract γPb cross sections.
- Add this to the draft of the paper and send it to IRC

Hopefully all of this, will happen in the next few days …